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NORTHERN UNIVERSITY

B A N G L A D E S H

SOLAR ENERGY OPTIMIZATION USING ARDUINO BASED MAXIMUM POWER POINT TRACKING SYSTEM

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MARCH 2016

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DECLARATION

We hereby, declare that the work presented in this project, titled, “**Solar Energy Optimization Using Arduino Based Maximum Power Point Tracking System**” is the outcomes of the research work performed by us. We also declare that all the information and implementation of this thesis is our independent effort except otherwise specified. We also certify that this project has never been submitted for academic or employment credit.

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This is to certify that the project, titled, “**Solar Energy Optimization Using Arduino Based Maximum Power Point Tracking System**”, submitted by **Md. Masum Bella**, ID: EEEE-130100283, **Chayan Biswas**, ID: EEEE-130100296, **Pallob Das**, EEEE-130100297, has been carried out under our supervision. It has been carried out in partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Electrical and Electronic Engineering in year of 2016 and has been approved as to its style and contents.

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ABSTRACT

Now a day's solar power is very helpful in our everyday life. This power is used in many ways such as homemade electrical appliances, vehicles, satellites and industries etc. The title of this project is **“Solar Energy Optimization Using Arduino Based Maximum Power Point Tracking System”**. In simple terms this project's objective is to have a solar panel outputting its maximum possible power all day long, this occurs when the panel tracks the sun and rotates the accordingly, to receive sunlight to the fullest extent always during the day time. This movement is achieved by installing a couple of servo motors with the solar panel that changes its direction according to the positioning of the sun. There are basically three major parts of this project, sensor, microcontroller and two servo motors. ATmega328 microcontrollers have been used for this purpose. It receives sensor output signal and controls servo motors according to the assigned program. One servo motor is used horizontally to move the panel upward and downward. The other is used vertically from left to right direction. As the solar panel is connected in servo motor so the position of solar panel is same to the servo motor. Since the maximum solar ray is fallen down on the solar panel module so that the maximum power output can be achieved.

ACKNOWLEDGEMENTS

First of all, we are grateful to Allah, the Almighty, the Merciful without whose patronage and blessing this project would not have been successfully completed. He gave us zeal, power of determination and courage and vanquished all the stumbling hardness that we faced on the way.

It is an auspicious occasion for us as students of Department of Electrical and Electronics Engineering, one of the prestigious academic centers of the Northern University Bangladesh, to express our deep feelings of gratitude to the Department and especially to our supervisor, Head of the Department, teachers and also to the department staff.

At the very beginning, we would like to present our immense gratitude and delightful thanks to our supervisor **Ashraful Arefin**, Assistant Professor, Department of EEE, NUB for giving us an opportunity to work on this subject, in which we found interest compared to conventional course works. From the beginning, he supported us with incessant generosity.

We would also like to extend our warmest thanks to all the faculty members of our department as well as the head of the department, **Dr. Moinul Islam Buyin**.

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Chapter 1

Introduction

1.1 What is Renewable Energy?

Renewable energy is energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat—which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transportation.

Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

1.2 Various Types of Renewable Energy

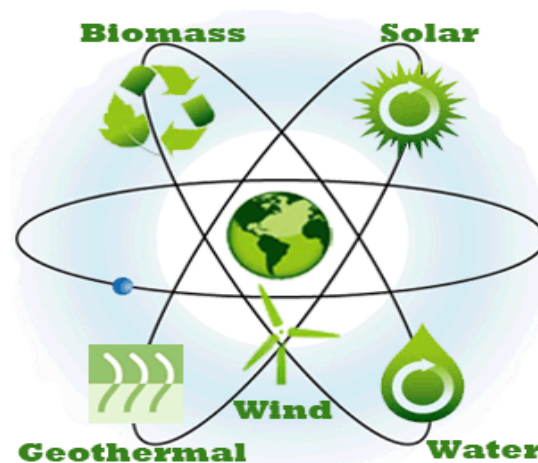


Fig.1.1: Various Types of Renewable Energy

Whenever you listen to the word green power, you might be amazed in order to additionally listen to which there are various kinds of green power. Essentially, green power indicates power that may restore by itself forever. Therefore in contrast to non-renewable causes of power (such as fossil energy sources), green power resources may regenerate on their own forever. For instance, solar energy would depend about the sunlight as well as blowing wind

energy would depend about the blowing wind. Nevertheless, nor sunlight neither the actual blowing wind may reduce, because they will still be existing so long as Planet is available. Therefore you don't have to be worried about green power resources through becoming exhausted. Additionally, just about all green causes of power have been in common eco-friendly and therefore additionally, you will be considered a participator within safeguarding your own atmosphere.

The different kinds of green power resources tend to be:

- 1) Solar Photovoltaic Energy
- 2) Hydro electrical power
- 3) Wind Power
- 4) Bioenergy
- 5) Solar Thermal Energy
- 6) Geothermal Power
- 7) Wave Power
- 8) Tidal Power

As possible observe, the actual kinds of green power which you can use are very varied. Of those numerous green power kinds; solar energy, blowing wind energy as well as geothermal power may be used separately to provide energy for the house. You can observe numerous houses which have solar power panels to create electrical power as well as warm water and you will additionally observe houses which make use of geothermal sends with regard to heating system.

Nevertheless, the actual answer about the worldwide size depends upon utilizing these types of power resources to create electrical power along with other types of power on the substantial size. Therefore to have this particular, there are numerous kinds of green power vegetation all over the globe. The most typical kind of green power vegetation are most likely hydroelectric energy programs that are put together close to streams along with other moving physiquess associated with drinking water.

Furthermore, blowing wind power vegetation will also be getting well-liked all over the globe. Blowing wind farming tend to be built to ensure that 20 or even more blowing wind generators tend to be built collectively to be able to increase the actual electric result from the

blowing wind energy grow. Obviously, other styles associated with green power will also be utilized. You will find geothermal submission vegetation in certain areas of the planet as well as tidal power and also the influx power tends to be utilized in certain sea shorelines all over the world.

1.3 Objective of this Project

1. The main objective of this project is to track the sun and rotate the solar panel accordingly, to receive sunlight to the fullest extent always during the day time.
2. How to optimization of solar energy using MPPT with an Arduino.
3. Look at the viability and technical feasibility of MPPT, looking in to the background of solar power globally and giving details on the different methods of MPPT.
4. How to using an Arduino in this system.
5. Design a DC-DC converter solution to connect the solar panel to the load.

1.4 Methodology

- Step 1: Studying on Microcontroller base solar system or Arduino base solar system.
- Step 2: Studying on servo mechanism.
- Step3: Studying on motor controlling system.
- Step4: Studying on MPP & MPPT system.
- Step5: Studying on voltage regulated system.
- Step6: Studying on solar tracking system.
- Step 7: Studying on solar panel system.
- Step 8: Studying on Porteus software.
- Step 9: Studying on programming C.
- Step10: Studying on sensor device.

1.5 Block Diagram

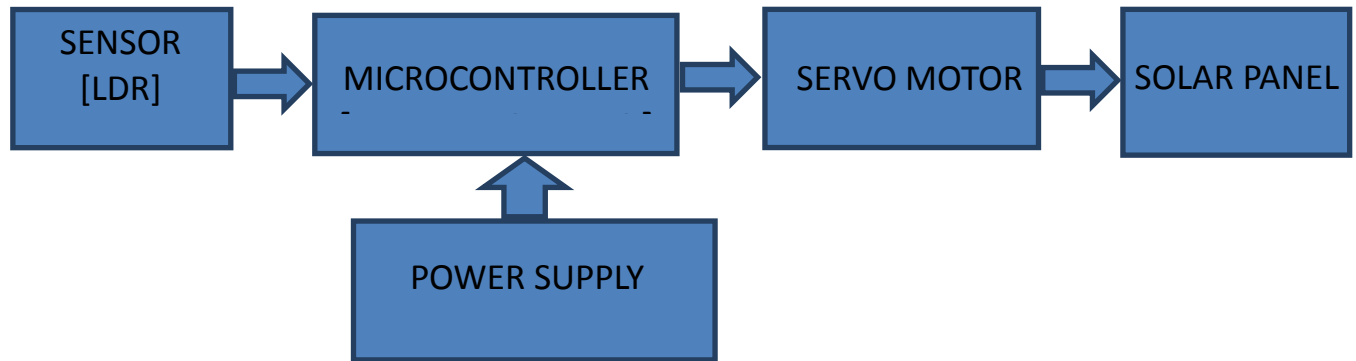


Fig.1.2: Block Diagram

1.6 Overview

In next chapter we will describe solar energy and MPPT, where we will elaborately describes Solar energy history, Definition, solar panel, working principle of solar panel, solar PV cell, Definition of MPP & MPPT, P&O method and advantage & disadvantage of MPPT etc.

In chapter Three we will describes elaborately Microcontroller Definition, Types, AVR Microcontroller, Arduino Definition, Types, How to program an Arduino, Arduino Architecture, Pin diagram, servo motor Definition, working principle, servo motor control, LDR Definition , working principle , construction of a photo cell, Characteristics of LDR etc.

Then in chapter Four we will describes elaborately Circuit Simulation & Construction such as voltage regulator circuit, block diagram, circuit diagram with working principle, project view & software requirements etc.

Lastly, in chapter Five will describes Conclusion, future prospects etc. and the end we will describes references and Arduino operating code.

Chapter 2

Solar Energy & MPPT

2.1 History of Solar energy

The history of solar energy is as old as humankind. In the last two centuries, we started using Sun's energy directly to make electricity. In 1839, Alexandre Edmond Becquerel discovered that certain materials produced small amounts of electric current when exposed to light.

2.1.1 Solar energy definition

The energy the Earth receives from the sun, primarily as visible light and other forms of electromagnetic radiation. (See renewable resource.) Note: The term solar energy often refers to processes that use this energy to generate heat or electricity for human use.

2.1.2 Solar Energy System

Solar energy is the cleanest and most available renewable energy source. The Modern technology can harness this energy for a variety of uses, including producing electricity, providing light and heating water for domestic, commercial or industrial application.

Solar energy can also be used to meet our electricity requirements. Through solar photovoltaic (SPV) cells, solar radiation gets converted into DC electricity directly. This electricity can either be used as it is or can be stored in the battery. In this article we are going to see all about the solar energy. Let's see step by step:

2.1.3 Solar Photovoltaic (SPV) Cell

A solar photovoltaic or solar cell is a device that converts light into electric current using the photoelectric effect. SPVs are used in many applications such as railway signals, street lighting, domestic lighting and powering of remote telecommunication systems.

It has a p-type of silicon layer placed in contact with an n-type silicon layer and the diffusion of electrons occurs from the n-type material to the p-type material. In the p-type material,

there are holes for accepting the electrons. The n-type material is rich in electrons, so by the influence of the solar energy, the electrons move from the n- type material and in the p-n junction, the combine with holes. This creates a charge on either side of the p-n junction to create an electric field. As a result of this, a diode like system develops which promotes charge flow. This is the drift current that balances the diffusion of electrons and holes. The area in which drift current occurs is the depletion zone or space charge region that lacks the mobile charge carriers.

So in dark, the solar cell behaves like a reverse biased diode. When light falls on it, like diode the solar cell forward biases and current flows in one direction from anode to cathode like a diode. Usually the open circuit (without connecting the battery) voltage of a solar panel is higher than its rated voltage. For example a 12 volt panel gives around 20 volts in bright sun light. But when the battery is connected to it, the voltage drops to 14-15 volts. Solar photovoltaic (SPV) cells are made of extraordinary materials called semiconductors for example silicon, which is presently the most generally used. Essentially, when light strikes the cell, a certain bit of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor.

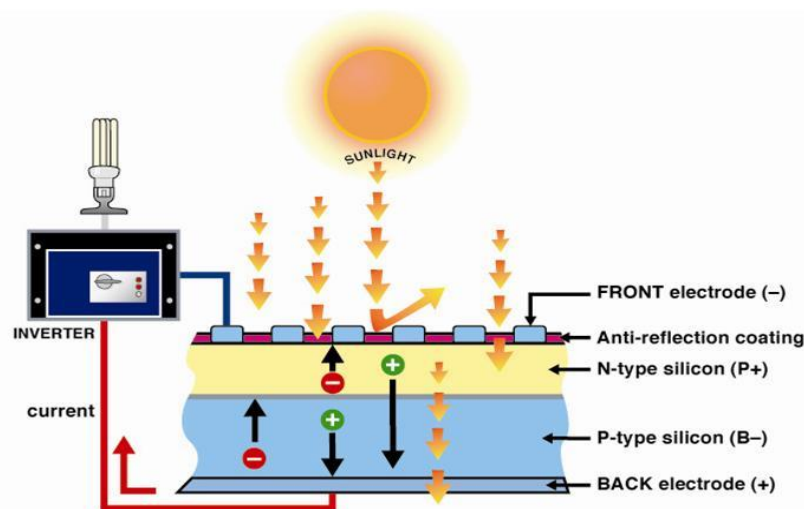


Fig. 2.1: Solar Photovoltaic (SPV) Cell

Solar PV cells also all have one or more electric fields that act to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current and by placing metal contacts on the top and bottom of the SPV cell, we can draw that current off to utilize remotely. The cells voltage defines the power that the solar cell can produce. The process of converting light into electricity is called the solar photovoltaic (SPV) effect.

An array of solar panels converts solar energy into DC electricity. The DC electricity then enters an inverter. The inverter turns DC electricity into 120-volt AC electricity needed by home appliances.

2.1.4 Solar Panel

A solar panel is a collection of solar cells. The solar panel converts the solar energy into electrical energy. The solar panel uses Ohmic material for interconnections as well as the external terminals. So the electrons created in the n-type material pass through the electrode to the wire connected to the battery. Through the battery, the electrons reach the p-type material. Here the electrons combine with the holes. So when the solar panel is connected to the battery, it behaves like another battery, and both the systems are in series just like two batteries connected serially.

2.1.5 Working Principle of Solar Panel

Output of the solar panel is its power which is measured in terms of Watts or Kilo watts. Solar panel with different output ratings is available like 5 watts, 10 watts, 20 watts, 100 watts etc. So before selecting the solar panel, it is necessary to find out the power required for the load. Watt hours or Kilowatt hours is used for calculating the power requirement. As a general rule, average power is equal to 20% of peak power. Therefore each peak kilo watt of solar array gives an output power that corresponds to the energy production of 4.8kWh / day. That is $24 \text{ hours} \times 1 \text{ kW} \times 20\%$.

Performance of the solar panel depends on a number of factors like climate, conditions of the sky, orientation of the panel, intensity and duration of sunlight and its wiring connections. If sunlight is normal, a 12 volt 15 watts panel gives around 1 ampere current. If properly maintained, a solar panel will last around 25 years. It is necessary to design the arrangement of solar panel on the roof top. Usually it is arranged facing the east at an angle of 45 degree. Solar tracking arrangement is also used that rotates the panel as the sun moves from east to west. Wiring connection is also important. Good quality wire with sufficient gauge to handle the current will ensure proper charging of the battery. If the wire is too lengthy, the charging current may reduce. So as a rule, the solar panel is arranged 10-20 feet height from the ground level. Proper cleaning of the solar panel once in month is recommended.

This includes cleaning of the surface to remove dust and moisture and cleaning and re connection of the terminals.

The solar panel has totally of four process steps overload, under charge, low battery and deep discharge condition, let's all them.

From the below circuit, we used a solar panel being a current source is used to charge the battery B1 via D10. While battery gets fully charged Q1 conducts from output of comparator. This results Q2 to conduct and divert the solar power through D11 and Q2 such that battery is not over charged. While the battery is fully charged the voltage at cathode point of D10 goes up. The current from solar panel is bypassed via D11 and the MOSFET drain and source. While the load is used by the switch operation Q2 usually provides a path to the negative while the positive is connected to the dc via the switch in the event over load. The correct operation of the load in normal condition is indicated by while the MOSFET Q2 conducts.

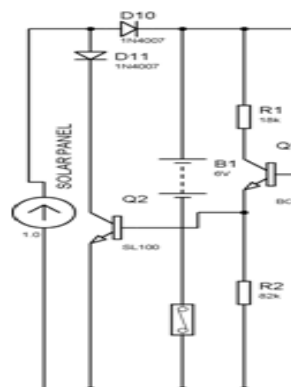


Fig. 2.2: circuit diagram

2.2 Definition of Maximum Power Point (MPP)

In photovoltaic systems, the point at which the most possible current is drawn from a cell and the voltage subsequently drops off. The MPP changes slightly with temperature and intensity of sunlight. Most photovoltaic (PV) systems have power conditioning electronics, called maximum power point trackers (MPPT) that constantly adjust the voltage in order to maximize power output. Simpler systems operate at a fixed voltage close to the optimal voltage.

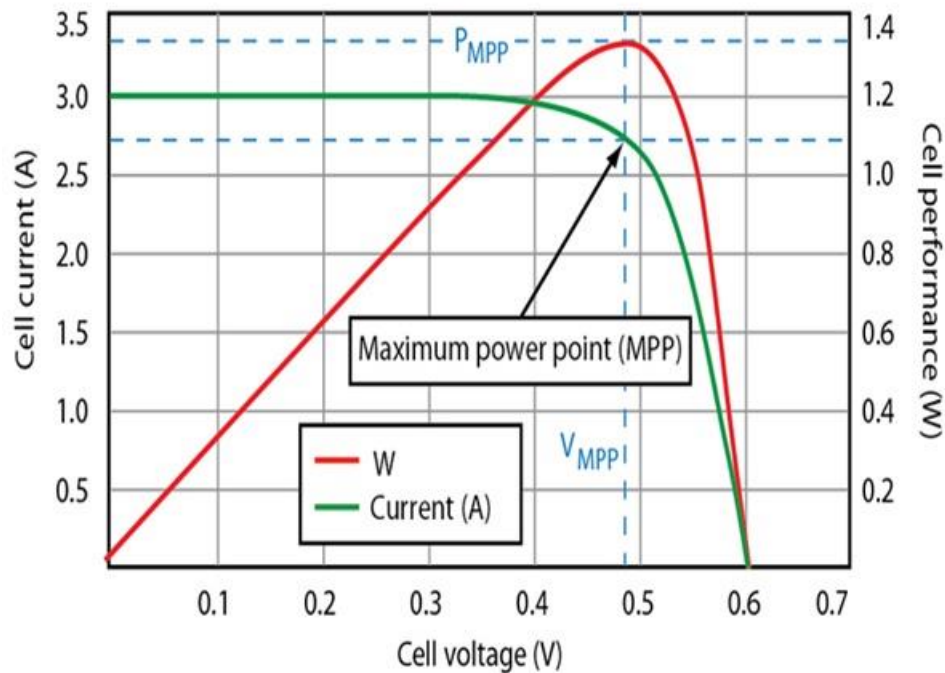


Fig. 2.3: C-V curve of MPP

2.3 Definition of Maximum Power Point Tracking (MPPT)

This is a method used in Solar PV arrays to expose uniform solar irradiance and maintain a maximum power output for a period of time. In figure 7 the maximum power output can clearly be seen at the 'knee' of the curve. This is the position that is most sought after and is achieved when maximum voltage and maximum current are achieved at the same time. MPPT is a method to ensure that maximum voltage and maximum current is reached as much as possible and overall to make maximum utilization of PV modules and minimize the power failure due to environmental conditions [13]. This is done by having the solar array track the path of the sun and also by making sure that none of the solar array becomes partially shaded at any stage due to cloud, branches of trees etc., and if this does occur a system is in place to adjust the panel and get it back to output the maximum current and voltage and hence the maximum output power. Details of the two methods used to track the MPP are given below;

the method that is being used in this project is the Perturb and Observe (P&O) method. If irradiance levels differ throughout the solar array, this results in multiple local maxima points being produced. This results in nonlinearity of the PV characteristic curves, which means there is more than one 'knee' in the P-V curve. Multiple local maxima are not good for tracking as it reduces the effectiveness of the tracking system, and these results in overall loss in power output.

2.3.1 How Maximum Power Point Tracking works

Here is where the optimization or maximum power point tracking comes in. Assume your battery is low, at 12 volts. A MPPT takes that 17.6 volts at 7.4 amps and converts it down, so that what the battery gets is now 10.8 amps at 12 volts. Now you still have almost 130 watts, and everyone is happy.

Ideally, for 100% power conversion you would get around 11.3 amps at 11.5 volts, but you have to feed the battery a higher voltage to force the amps in. And this is a simplified explanation - in actual fact the output of the MPPT charge controller might vary continually to adjust for getting the maximum amps into the battery.

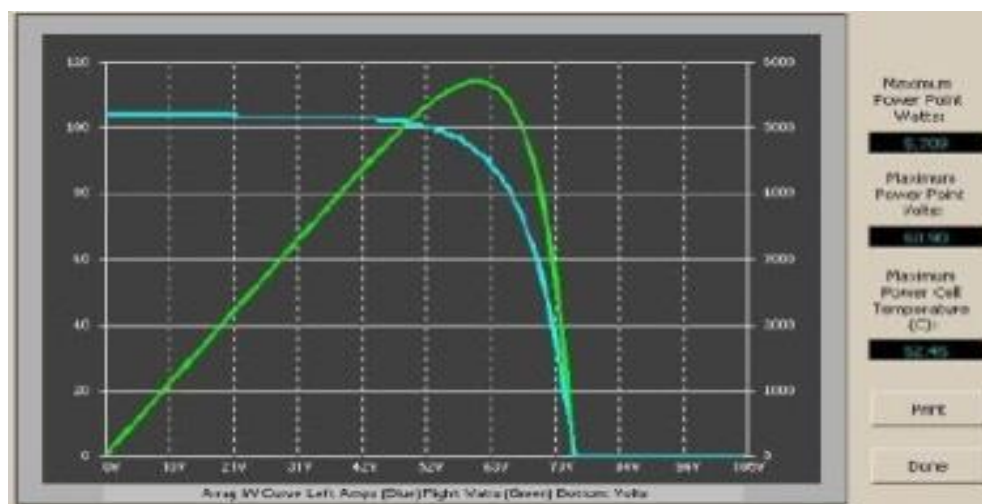


Fig: 2.4: MPPT Curve

On the left is a screen shot from the Maui Solar Software "PV-Design Pro" computer program (click on picture for full size image). If you look at the green line, you will see that it has a sharp peak at the upper right - that represents the maximum power point. What an MPPT controller does is "look" for that exact point, then does the voltage/current conversion

to change it to exactly what the battery needs. In real life, that peak moves around continuously with changes in light conditions and weather.

A MPPT tracks the maximum power point, which is going to be different from the STC (Standard Test Conditions) rating under almost all situations. Under very cold conditions a 120 watt panel is actually capable of putting over 130+ watts because the power output goes up as panel temperature goes down - but if you don't have some way of tracking that power point, you are going to lose it. On the other hand under very hot conditions, the power drops - you lose power as the temperature goes up. That is why you get less gain in summer.

2.3.2 MPPT's are most effective under these conditions

1. Winter and/or cloudy or hazy days - when the extra power is needed the most.
2. Cold weather - solar panels work better at cold temperatures, but without a MPPT you are losing most of that. Cold weather is most likely in winter - the time when sun hours are low and you need the power to recharge batteries the most.
3. Low battery charge - the lower the state of charge in your battery, the more current a MPPT puts into them - another time when the extra power is needed the most. You can have both of these conditions at the same time.
4. Long wire runs - If you are charging a 12 volt battery, and your panels are 100 feet away, the voltage drop and power loss can be considerable unless you use very large wire. That can be very expensive. But if you have four 12 volt panels wired in series for 48 volts, the power loss is much less, and the controller will convert that high voltage to 12 volts at the battery. That also means that if you have a high voltage panel setup feeding the controller, you can use much smaller wire.

2.3.3 Perturb and Observe (P&O) method of MPPT

This is an algorithm which is used as a method of MPPT. The P&O tracking process is carried out by observing the array output power and determining the next action, either to increase or decrease the array operating voltage. In recent times this method has been widely used to achieve the maximum amount of power from a solar panel.

The presence of multiple 20 local maximum power points, these occur when an entire PV array do not receive uniform solar irradiance, due to partial shading, reduce the effectiveness of this method greatly [21]. If the operating voltage of a PV array is perturbed in a given direction and if the power drawn from the PV array increases, this means that the operating point has moved towards the MPP and therefore, the operating voltage must be further perturbed in the same direction. Otherwise, if the power drawn from the PV array decreases, the operating point has moved away from the MPP and therefore, the direction of the operating voltage perturbation must be reversed.

2.3.4 The advantages of this method include

1. Very simple and easy to implement and does find true MPP.
2. It can be taken as either an Analog or Digital technique of MPPT.
3. Most commonly used so information is widely available.
4. Provides predictive and accurate solutions to MPPT under PSC.
5. No oscillation during tracking and steady state operations

2.3.5 The disadvantages of this method include

1. Under rapidly varying irradiance & load conditions the system can track in the wrong direction.
2. The size of the change in operation voltage chosen determines the speed & convergence of the MPP and the range of oscillation.

Chapter 3

Equipment's

3.1 Equipment's List

- 1.Arduino-(UNO)
2. Servo Motor
- 3.LED
4. LDR
5. 5V Voltage regulator(7805)
6. Capacitors(47UF,100UF)
7. Resistor (1K, 220hom)
- 8.Diode
9. Transistor(BC 548)
10. Battery(8v)
11. Connecting wire
12. Vero board
- 13.Soldering iron, Soldering led
14. Solar panel

3.2 Definition of microcontroller

A microcontroller is a compact microcomputer designed to govern the operation of embedded systems in motor vehicles, robots, office machines, complex medical devices, mobile radio transceivers, vending machines, home appliances, and various other devices. A typical microcontroller includes a processor, memory, and peripherals.

The simplest microcontrollers facilitate the operation of the electromechanical systems found in everyday convenience items. Originally, such use was confined to large machines such as furnaces and automobile engines to optimize efficiency and performance. In recent years, microcontrollers have found their way into common items such as ovens, refrigerators, toasters, clock radios, and lawn watering systems. Microcomputers are also common in office machines such as photocopiers, scanners, fax machines, and printers.

The most sophisticated microcontrollers perform critical functions in aircraft, spacecraft, ocean-going vessels, life-support systems, and robots of all kinds. Medical technology offers especially promising future roles. For example, a microcontroller might regulate the operation of an artificial heart, artificial kidney, or other artificial body organ. Microcomputers can also function with prosthetic devices (artificial limbs). A few medical-science futurists have suggested that mute patients might someday be able, in effect, to speak out loud by thinking of the words they want to utter, while a microcontroller governs the production of audio signals to drive an amplifier and loudspeaker.

3.2.1 Different Types of Micro-Controller

There are so many microcontroller families are available. Those are:

8051, PIC (Programmable interface controller), AVRARM, etc.

3.2.2 What is AVR Microcontroller?

An AVR microcontroller is a type of device manufactured by Atmel, which has particular benefits over other common chips, but first what is a microcontroller?

The easiest way of thinking about it is to compare a microcontroller with your PC, which has a motherboard in it. On that motherboard is a microprocessor (Intel, AMD chips) that provides the intelligence, RAM and EEPROM memories and interfaces to rest of system, like serial ports (mostly USB ports now), disk drives and display interfaces. A microcontroller has all or most of these features built-in to a single chip, so it doesn't need a motherboard and many components, LEDs for example, can be connected directly to the AVR. If you tried this with a microprocessor, bang! PC microprocessors are always at least 32-bit and commonly now 64-bit. This means that they can process data in 32-bit or 64-bit chunks as they are connected to data buses this wide. The AVR is much simpler and deals with data in 8-bit chunks as its data bus is 8-bit wide, although there is now an AVR32 with 32-bit bus.

A PC has an operating system (Windows or Linux) and this runs programs, such as Word or Internet Explorer or Chrome that do specific things. An 8-bit microcontroller like the AVR doesn't usually have an operating system, although it could run a simple one if required, and instead it just runs a single program.

Just as your PC would be useless if you didn't install any programs, an AVR must have a program installed to be any use. This program is stored in memory built-in to the AVR, not on an external disk drive like a PC. Loading this program into the AVR is done with an AVR programmer, usually when the AVR is in a circuit or system, hence AVR ISP or AVR In System Programmer.

3.2.3 Definition of Embedded Systems

- A combination of hardware and software which together form a component of a larger machine.
- An example of an embedded system is a microprocessor that controls an automobile engine.
- An embedded system is designed to run on its own without human intervention, and may be required to respond to events in real time.

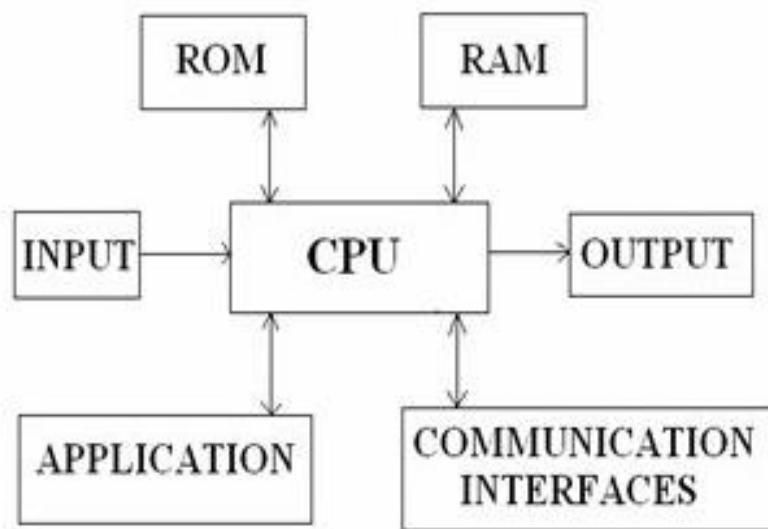


Fig. 3.1: Embedded Systems

3.2.4 What is a program?

A program is a series of instructions, each very simple, that fetch and manipulate data. In most applications where you would use an AVR, such as a washing machine controller for example, this means reading inputs, checking their state and switching on outputs accordingly. Sometimes you may need to modify or manipulate the data, or transmit it to another device, such as an LCD or serial port. A series of simple binary instructions are used to do these basic tasks and each one has an equivalent assembly language instruction that humans can understand. The most basic way of writing a program for an AVR is to use assembly language (although you could write binary numbers if you want to be pedantic).

Using assembly language allows you to understand far more about the operation of the AVR and how it is put together. It also produces very small and fast code. The disadvantage is that you as the programmer have to do everything, including memory management and program structure, which can get very tedious.

To avoid this, high level languages are increasingly being used to write programs for the AVR, C in particular but also Basic and Java derivatives. High level means that each line of C (or Basic or Java) code can translate into many lines of assembly language. The compiler also deals with the program structure and memory management so it is much easier. Commonly used routines, such as delays or math, can also be stored in libraries and reused very easily.

In my opinion, writing AVR programs in C is like driving a car. Yes you can do it very easily but if something goes wrong you haven't got a clue how to fix it and you can't deal with tricky situations like icy roads. Starting with assembly language and writing some simple programs lets you understand what is going on "under the hood" so you know how it works and can get the most out of it. Then swap to C by all means but at least you know how the AVR fits together and its limitations.

As well as having code memory for your program, the AVR has a second memory called EEPROM where you can store user data, like serial numbers, calibration data and other information that needs to be preserved. It is accessed by instructions in your program.

AVRs also have an I/O space, which is used to control the hardware of the microcontroller. This includes ports, ADC, communication interfaces like I2C (2-wire interface), SPI and UART (serial port), timers and watchdogs that recover from system crashes. All these peripherals are controlled from your program using special instructions. A lot of AVR code programming is about how to setup and control this hardware interface.

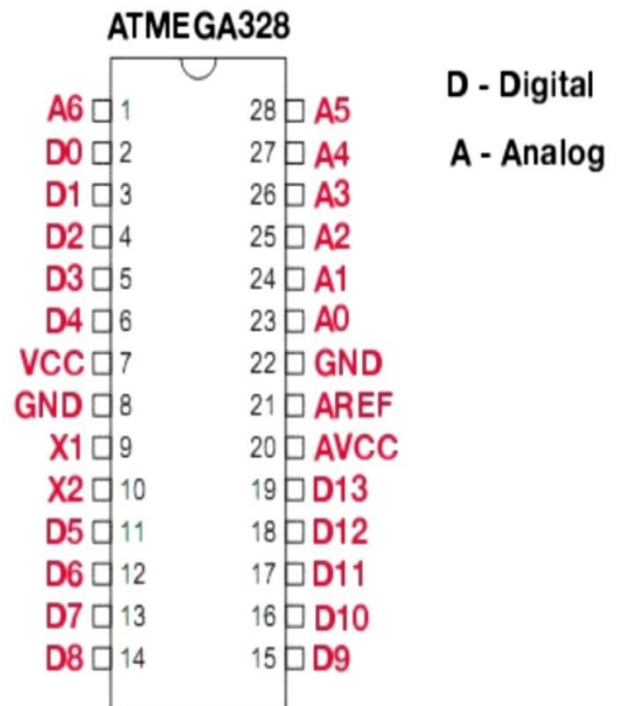
3.2.5 ATmega-328

The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

3.2.6 Key parameters for ATmega-328

Parameter	Value
-----------	-------

Flash (Kbytes) :	32 Kbytes
Pin Count:	32
Max. Operating Freq. (MHz):	20 MHz
CPU:	8-bit AVR
# of Touch Channels:	16
Hardware QTouch Acquisition:	No
Max I/O Pins:	23
Ext Interrupts:	24
USB Speed:	No
USB Interface:	No
SPI:	2
TWI (I2C):	1
UART:	1
Graphic LCD:	No
Video Decoder:	No
Camera Interface:	No
ADC Channels:	8
ADC Resolution (bits):	10
ADC Speed (ksps):	15
Analog Comparators:	1
Resistive Touch Screen:	No
DAC Resolution (bits):	0
Temp. Sensor:	Yes
Crypto Engine:	No
SRAM (Kbytes):	2
EEPROM (Bytes):	1024
Self-Program Memory:	Yes
External Bus Interface:	0
DRAM Memory:	No
NAND Interface:	No
Pico Power:	No
Temp. Range (deg C):	-40 to 85
I/O Supply Class:	1.8 to 5.5
Operating Voltage (V _{cc}):	1.8 to 5.5
FPU:	No
MPU / MMU:	no / no
Timers:	3
Output Compare Channels:	6
Input Capture Channels:	1
PWM Channels:	6
32kHz RTC:	Yes
Calibrated RC Oscillator:	Yes
Watchdog:	Yes
CAN:	0
LIN:	0
Ethernet:	0
Debug Interface:	1 debug Wire
I2S:	No
RTC:	Counter



3.3 Arduino

An Arduino is actually a microcontroller based kit which can be either used directly by purchasing from the vendor or can be made at home using the components, owing to its open source hardware feature. It is basically used in communications and in controlling or operating many devices. It was founded by Massimo Banzi and David Cuartielles in 2005.

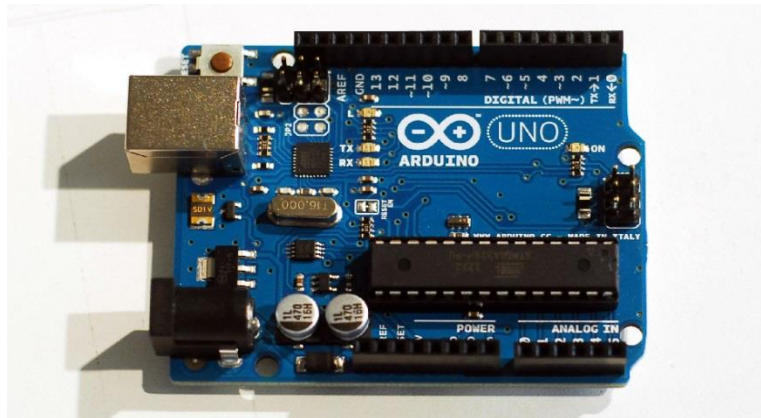


Fig. 3.2: Arduino

List of Arduino boards and compatible systems

The original Arduino hardware was manufactured by the Italian company Smart Projects. Some Arduino-branded boards have been designed by the American companies Spark Fun Electronics and Adafruit Industries. Seventeen versions of the Arduino hardware have been commercially produced to date.

Example Arduino boards

1. Arduino Diecimila in Stoicheia
2. Arduino Duemilanove (rev 2009b)
3. Arduino UNO
4. Arduino Leonardo
5. Arduino Mega
6. Arduino MEGA 2560 R3 (front side)
7. Arduino MEGA 2560 R3 (back side)
8. Arduino Nano
9. Arduino Due (ARM Cortex-M3 core)
10. LilyPad Arduino (rev 2007)
11. Arduino Yun

3.3.1 Arduino Architecture

Arduino's processor basically uses the Harvard architecture where the program code and program data have separate memory. It consists of two memories- Program memory and the data memory. The code is stored in the flash program memory, whereas the data is stored in the data memory. The Atmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for the boot loader), 2 KB of SRAM and 1 KB of EEPROM and operates with a clock speed of 16MHz.

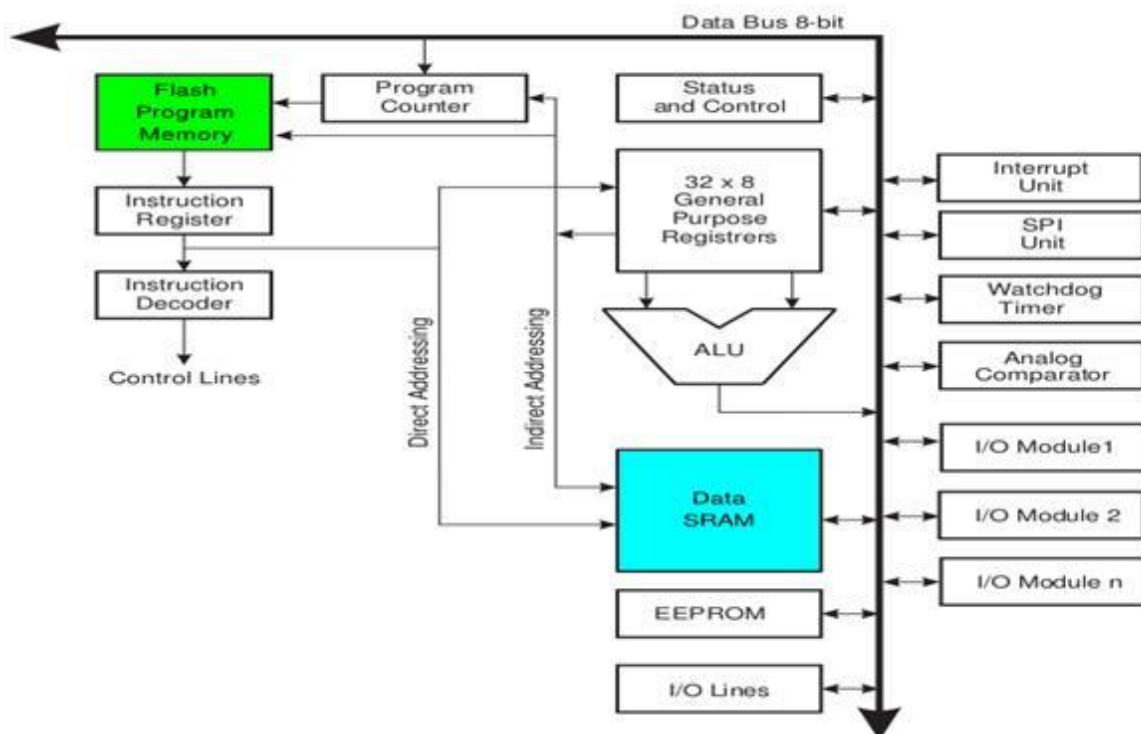


Fig. 3.3:Arduino Architecture

3.3.2 Arduino Pin Diagram

A typical example of Arduino board is Arduino Uno. It consists of ATmega328- a 28 pin microcontroller.

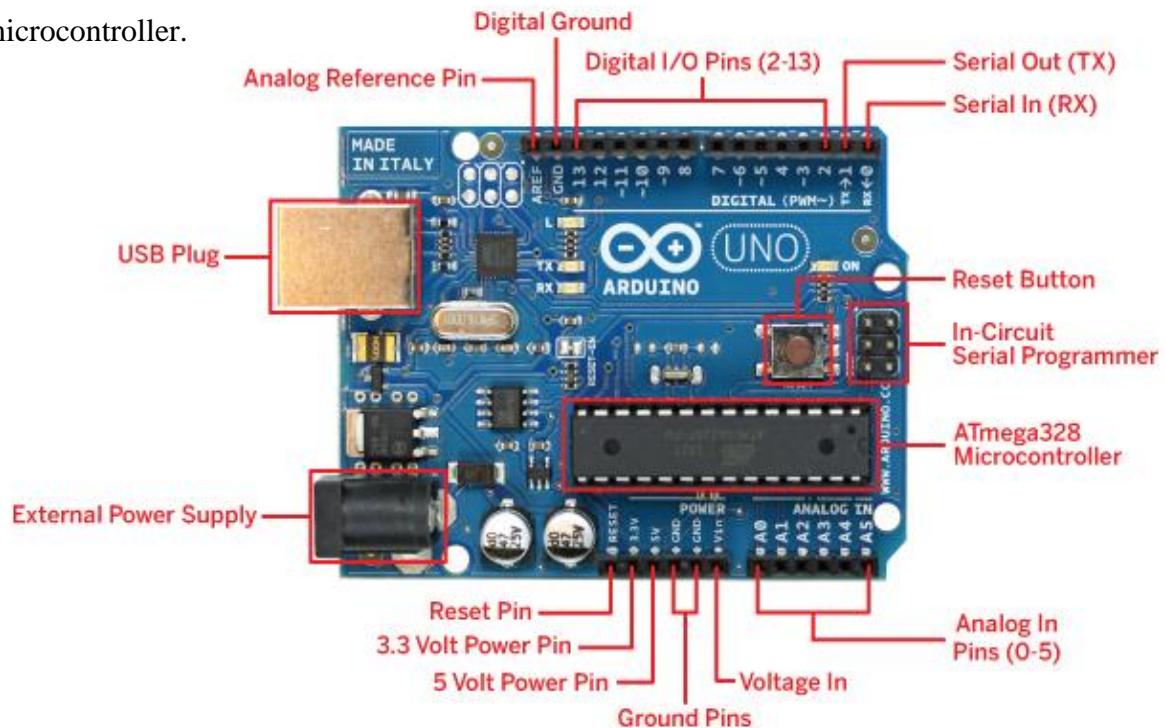


Fig. 3.4: Arduino Pin Diagram

Arduino Uno consists of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Power Jack: Arduino can be power either from the pc through a USB or through external source like adaptor or a battery. It can operate on a external supply of 7 to 12V. Power can be applied externally through the pin Vin or by giving voltage reference through the IO Ref pin.

Digital Inputs: It consists of 14 digital inputs/output pins, each of which provide or take up 40mA current. Some of them have special functions like pins 0 and 1, which act as Rx and Tx respectively , for serial communication, pins 2 and 3-which are external interrupts, pins 3,5,6,9,11 which provides PWM output and pin 13 where LED is connected.

Analog inputs: It has 6 analog input/output pins, each providing a resolution of 10 bits.

ARef: It provides reference to the analog inputs

Reset: It resets the microcontroller when low.

3.3.3 How to program an Arduino?

The most important advantage with Arduino is the programs can be directly loaded to the device without requiring any hardware programmer to burn the program. This is done because of the presence of the 0.5KB of Boot loader which allows the program to be burned into the circuit. All we have to do is to download the Arduino software and writing the code.

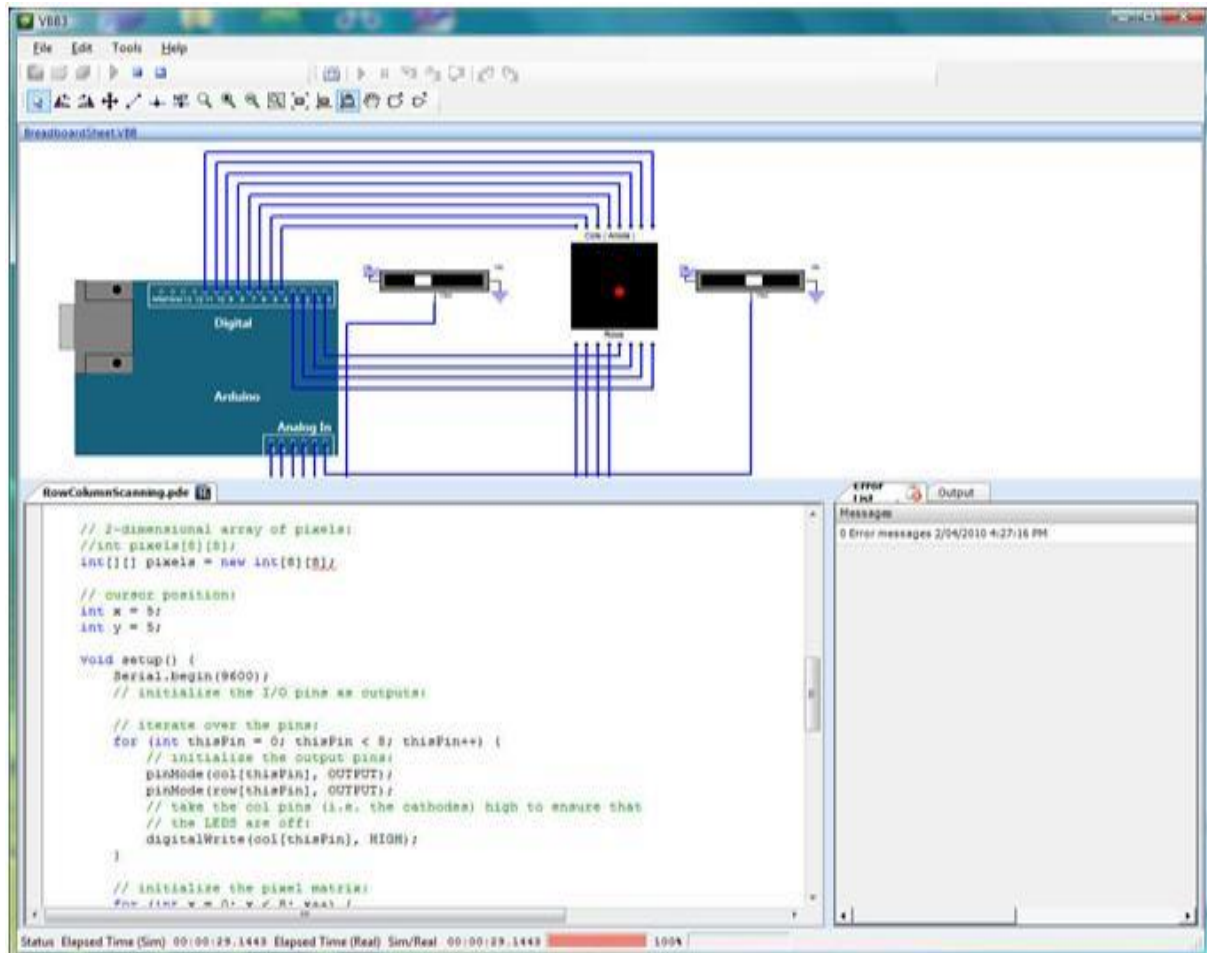


Fig.3.5:program an Arduino

The Arduino tool window consists of the toolbar with the buttons like verify, upload, new, open, save, serial monitor. It also consists of a text editor to write the code, a message area which displays the feedback like showing the errors, the text console which displays the output and a series of menus like the File, Edit, and Tools menu.

3.3.4 5 Steps to program an Arduino

Programs written in Arduino are known as sketches. A basic sketch consists of 3 parts

1. Declaration of Variables
2. Initialization: It is written in the setup () function.
3. Control code: It is written in the loop () function.

The sketch is saved with .ino extension. Any operations like verifying, opening a sketch, saving a sketch can be done using the buttons on the toolbar or using the tool menu.

The sketch should be stored in the sketchbook directory.

Chose the proper board from the tools menu and the serial port numbers.

Click on the upload button or chose upload from the tools menu. Thus the code is uploaded by the boot loader onto the microcontroller.

3.3.5 Few of basic Adruino functions are

Digital Read(pin): Reads the digital value at the given pin.

Digital Write(pin, value): Writes the digital value to the given pin.

Pin Mode(pin, mode): Sets the pin to input or output mode.

Analog Read(pin): Reads and returns the value.

Analog Write(pin, value): Writes the value to that pin.

Serial begin(baud rate): Sets the beginning of serial communication by setting the bit rate.

3.3.6 How to Design your own Arduino?

1. We can also design our own Arduino by following the schematic given by the Arduino vendor and also available at the websites. All we need are the following components- A breadboard, a led, a power jack, a IC socket, a microcontroller, few resistors, 2 regulators, 2 capacitors.
2. The IC socket and the power jack are mounted on the board.
3. Add the 5v and 3.3v regulator circuits using the combinations of regulators and capacitors.
4. Add proper power connections to the microcontroller pins.
5. Connect the reset pin of the IC socket to a 10K resistor.
6. Connect the crystal oscillators to pins 9 and 10
7. Connect the led to the appropriate pin.

8. Mount the female headers onto the board and connect them to the respective pins on the chip.
9. Mount the row of 6 male headers, which can be used as an alternative to upload programs.
10. Upload the program on the Microcontroller of the readymade Arduino and then pry it off and place back on the user kit.

3.3.7 7 Reasons why Arduino is being preferred these days

1. It is inexpensive
2. It comes with an open source hardware feature which enables users to develop their own kit using already available one as a reference source.
3. The Arduino software is compatible with all types of operating systems like Windows, Linux, and Macintosh etc.
4. It also comes with open source software feature which enables experienced software developers to use the Arduino code to merge with the existing programming language libraries and can be extended and modified.
5. It is easy to use for beginners.
6. We can develop an Arduino based project which can be completely stand alone or projects which involve direct communication with the software loaded in the computer.
7. It comes with an easy provision of connecting with the CPU of the computer using serial communication over USB as it contains built in power and reset circuitry.
8. So this is some basic idea regarding an Arduino. You can use it for many types of applications. For instance in applications involving controlling some actuators like motors, generators, based on the input from sensors

3.4 Servo Motor

This is nothing but a simple electrical motor, controlled with the help of servomechanism. If the motor as controlled device, associated with servomechanism is DC motor, then it is commonly known DC Servo Motor. If the controlled motor is operated by AC it is called AC Servo Motor.

3.4.1 Servo Motor Theory

There are some special types of application of motor where rotation of the motor is required for just a certain angle not continuously for long period of time. For these applications some special types of motor are required with some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). For this purpose servo motorhome's into picture. This is normally a simple DC which is controlled for specific angular rotation with help of additional servomechanism (a typical closed loop feedback control system). Now day's servo system has huge industrial applications. Servo motor applications are also commonly seen in remote controlled toy cars for controlling direction of motion and it is also very commonly used as the motor which moves the tray of a CD or DVD player. Beside these there are other hundreds of applications we see in our daily life. The main reason behind using a servo is that it provides angular precision, i.e. it will only rotate as much we want and then stop and wait for next signal to take further action. This is unlike a normal electrical motor which starts rotating as and when power is applied to it and the rotation continues until we switch off the power. We cannot control the rotational progress of electrical motor but we can only control the speed of rotation and can turn it ON and OFF.

Now we come to the specific answer of the question "what is servo motor?" "Servo motor is a special type of motor which is automatically operated up to certain limit for a given command with help of error-sensing feedback to correct the performance.



Fig. 3.6: Servo Motor

3.4.2 Servo-mechanism

A servo system mainly consists of three basic components - a controlled device, a output sensor, a feedback system. This is an automatic closed loop control system. Here instead of controlling a device by applying variable input signal, the device is controlled by a feedback signal generated by comparing output signal and reference input signal. When reference input signal or command signal is applied to the system, it is compared with output reference signal of the system produced by output sensor, and a third signal produced by feedback system. This third signal acts as input signal of controlled device. This input signal to the device presents as long as there is a logical difference between reference input signal and output signal of the system. After the device achieves its desired output, there will be no longer logical difference between reference input signal and reference output signal of the system. Then, third signal produced by comparing theses above said signals will not remain enough to operate the device further and to produce further output of the system until the next reference input signal or command signal is applied to the system. Hence the primary task of a servomechanism is to maintain the output of a system at the desired value in the presence of disturbances.

3.4.3 Working Principle of Servo Motor

A servo motor is basically a DC motor(in some special cases it is AC motor) along with some other special purpose components that make a DC motor a servo. In a servo unit, you will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The intelligent circuitry along with the potentiometer makes the servo to rotate according to our wishes.

As we know, a small DC motor will rotate with high speed but the torque generated by its rotation will not be enough to move even a light load. This is where the gear system inside a servomechanism comes into picture. The gear mechanism will take high input speed of the motor (fast) and at the output we will get a output speed which is slower than original input speed but more practical and widely applicable.

Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer . This output port of the potentiometer is connected with one of the input terminals of the error detector

amplifier. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from external source, will be amplified in the error detector amplifier and feeds the DC motor. This amplified error signal acts as the input power of the dc motor and the motor starts rotating in desired direction. As the motor shaft progresses the potentiometer knob also rotates as it is coupled with motor shaft with help of gear arrangement. As the position of the potentiometer knob changes there will be an electrical signal produced at the potentiometer port. As the angular position of the potentiometer knob progresses the output or feedback signal increases. After desired angular position of motor shaft the potentiometer knob is reaches at such position the electrical signal generated in the potentiometer becomes same as of external electrical signal given to amplifier. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer . As the input signal to the motor is nil at that position, the motor stops rotating. This is how a simple conceptual servo motor works.

3.4.4 Servo Motor Control

For understanding servo motor control let us consider an example of servomotor that we have given a signal to rotate by an angle of 45° and then stop and wait for further instruction.

The shaft of the DC motor is coupled with another shaft called output shaft, with help of gear assembly. This gear assembly is used to step down the high rpm of the motor's shaft to low rpm at output shaft of the servo system.

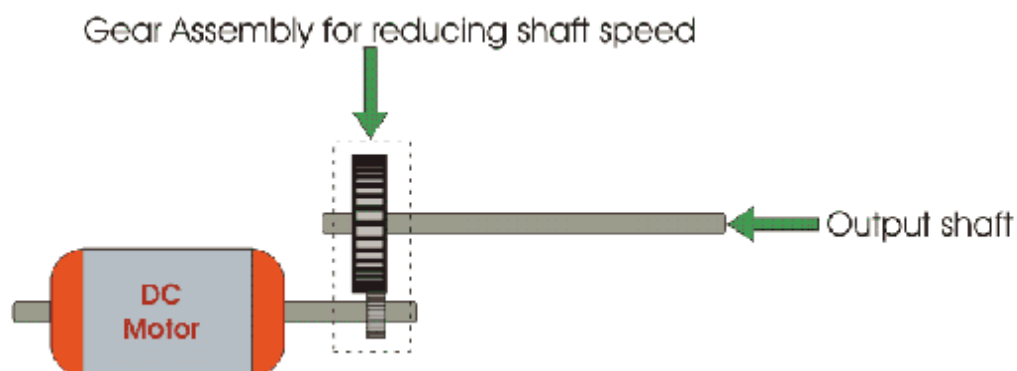


Fig. 3.7: Servo Motor Control

Gear Assembly for reducing shaft speed

DC Motor

Position cog

Output shaft

Potentiometer

shaft increases from 0° to 45°

The diagram illustrates a closed-loop speed control system for a DC motor. The components and their interconnections are as follows:

- DC Motor:** The primary actuator, shown as a cylinder with red ends. It receives an **Electrical Input to DC Motor** from the negative terminal of the error detector amplifier.
- Gear Assembly for reducing shaft speed:** A dashed box containing a small gear on the motor shaft and a larger gear on the output shaft, used for speed reduction.
- Output shaft:** The shaft whose speed is being controlled, connected to the large gear in the gear assembly.
- Position cog:** A cogwheel mounted on the output shaft, which is part of the feedback mechanism.
- Potentiometer:** A feedback sensor that converts the mechanical position into an electrical signal.
- Reference Input Signal:** The desired speed setpoint, applied to the positive terminal of the error detector amplifier.
- Reference Output Signal:** A signal derived from the potentiometer, fed back to the negative terminal of the error detector amplifier.
- Error detector amplifier (A):** A triangular block that compares the reference input and reference output signals to generate an error signal.
- Feedback path:** Indicated by a dashed arrow, it shows the signal flow from the potentiometer through the error detector amplifier back to the DC motor.

e the output electrical voltage

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further movement of the shaft in desired direction. From this example we can understand the most basic servo motor theory and how servo motor control is achieved. NB: Although in practical servo motor control system, instead of using simple potentiometer we use digital or analog position sensor encoder.

From this basic working principle of servo motor it can be concluded. The shaft of the servo is connected to a potentiometer . The circuitry inside the servo, to which the potentiometer is connected, knows the position of the servo. The current position will be compared with the desired position continuously with the help of an Error Detection Amplifier. If a mismatch is found, then an error signal is provided at the output of the error amplifier and the shaft will rotate to go the exact location required. Once the desired location is reached, it stops and waits.

3.4.5 Continuous Rotation Servo Motors

Continuous rotation servo motors are actually a modified version of what the servos are actually meant to do, that is, control the shaft position. The 360° rotation servos are actually made by changing certain mechanical connections inside the servo. However, certain manufacturer like parallax sells these servos as well. With the continuous rotation servo you can only control the direction and speed of the servo, but not the position. Two of the most popular Servo motor manufacturers are FUTABA and HITEC.

3.5 Light Dependent Resistor or a Photo Resistor

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices.

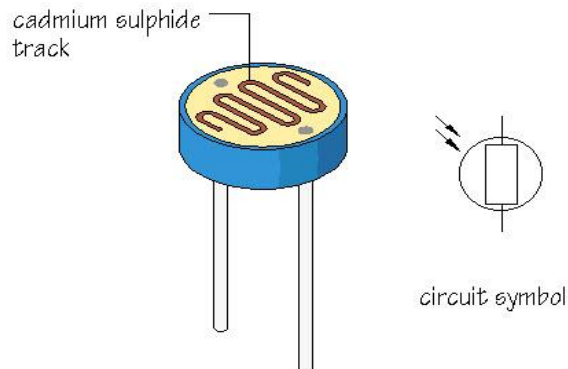


Fig. 3.10: Photo Resistor

They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

Types of light Dependent Resistors:

Light dependent resistors are classified based on the materials used.

Intrinsic Photo Resistors

These resistors are pure semiconductor devices like silicon or germanium. When the light falls on the LDR, then the electrons get excited from the valence band to the conduction band and number of charge carriers increases.

Extrinsic Photo Resistors

These devices are doped with impurities and these impurities create a new energy bands above the valence band. These bands are filled with electrons. Hence this decrease the band gap and small amount of energy is required in moving them. These resistors are mainly used for long wavelengths.

3.5.1 Construction of a Photocell

The structure of a light dependent resistor consists of a light sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in zigzag pattern in order to obtain the desired resistance & power rating. This zigzag area separates the metal deposited areas into two regions. Then the ohmic contacts are made on the either sides of the area. The resistances of these contacts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, indium antimonite and cadmium sulphonide. The use of lead and cadmium is avoided as they are harmful to the environment.

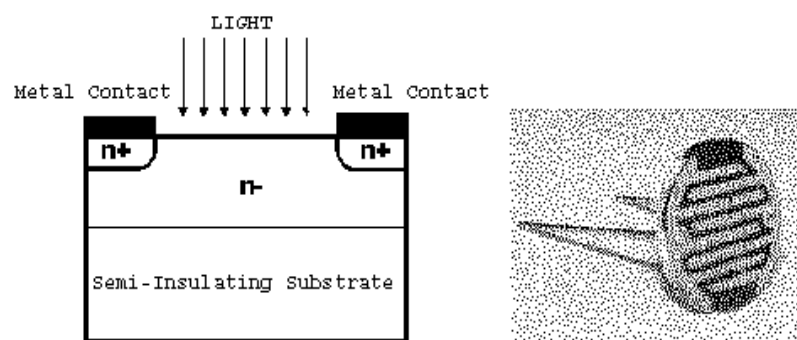


Fig. 3.11: Construction of a Photocell

3.5.2 Circuit Diagram of a Light Dependent Resistor

The circuit diagram of a LDR is shown below. When the light intensity is low, then the resistance of the LDR is high. This stops the current flow to the base terminal of the transistor. So, the LED does not light. However, when the light intensity onto the LDR is high, then the resistance of the LDR is low. So current flows onto the base of the first transistor and then the second transistor. Consequently the LED lights. Here, a preset resistor is used to turn up or down to increase or decrease the resistance.

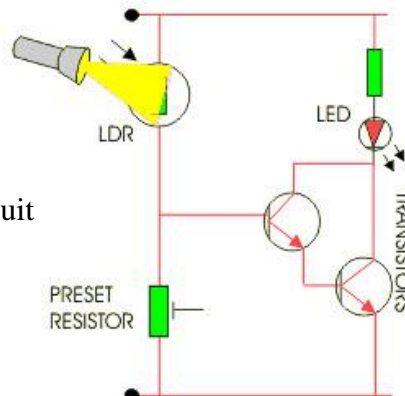


Fig. 3.12: Light Dependent Resistor Circuit

3.5.3 Working Principle of LDR

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

3.5.4 Characteristics of LDR

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as $10^{12} \Omega$ and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

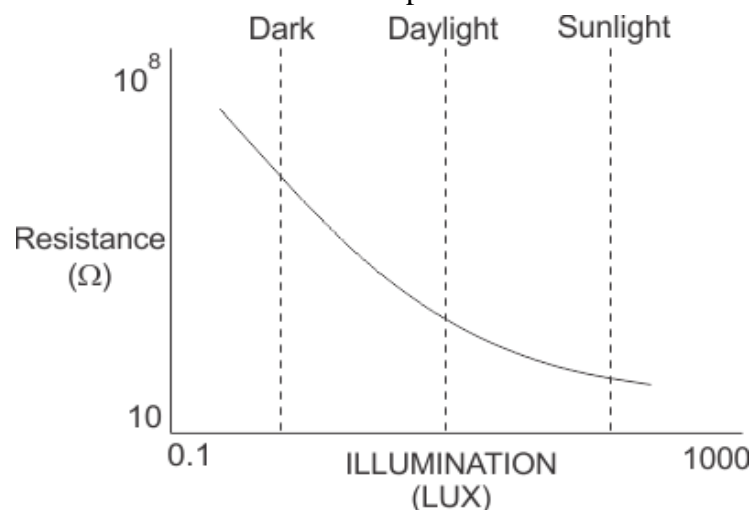


Fig. 3.13: Characteristics Curve

Photocells or LDR's are nonlinear devices. Their sensitivity varies with the wavelength of light incident on them. Some photocells might not at all respond to a certain range of

wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, LDR's are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it "converts" light to electricity).

3.5.5 Applications of LDR

LDR's have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

3.6 Light-emitting diode (LED)

Light - emitting diodes, also known as an LED, is a semiconductor light source. It emits light in response to the passage of electric current. The color of the light that it emits corresponds to the energy of the photons released, which is determined by the energy gap of the semiconductor. A diagram of what makes up an LED can be seen below.

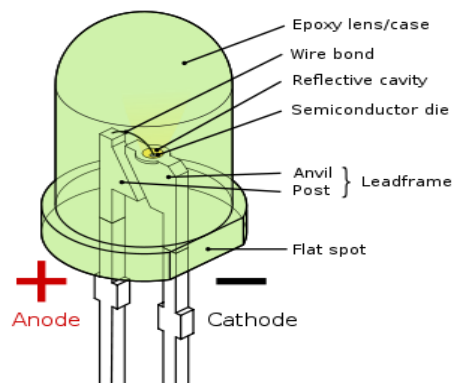


Fig. 3.13: Structure of LED

For the most part, you don't need to worry about any of that, but there are some properties of LEDs that you do need to be aware of.

Lens/Case - Casings come in the flavors, clear, colored clear, and a diffused colored. The diffused colored LEDs allow for a uniform distribution of light. The colored clear cases are used for a more focused light. Clear cases give the purest form of light. In the diagram above, you can see that the casing is often much larger than the diode. This means that if the case does not fit where you need it to, it can be trimmed. Be sure to not damage any of the diode components while trimming. If you do try to trim the casing using a hobby knife, be careful as it can chip and crack.

Color/Wavelength - This property determines what color the LED will give off. Values and the corresponding values are:

Violet: 390-450 nm

Blue: 450-475 nm

Cyan: 476-495 nm

Green: 495 - 570 nm

Yellow: 570 590 nm

Orange: 590 - 620 nm

Red: 620 - 750 nm

If you're looking to have a black light effect, you can find LEDs in the ultraviolet spectrum which ranges from 315 to 400 nm.

Forward Voltage - This is the voltage required to power the LED. For your standard green LED, this value is around 2V. Remember when selecting a battery, to go above the value for the resistor.

Maximum Current - This is the maximum current the diode can handle without risking damage. This value will be used to determine the size of the resistor.

Luminous Intensity - This is essentially the brightness of the LED. Generally, this is measured in mille-candela (mcd). The higher the number, the brighter the LED.

Chapter 4

Circuit Simulation& Construction

4.1 Voltage Regulator Circuit Using LM7805

Voltage regulator is a device that is used to make a voltage constant/ linear. Here this is a 5 Volt regulator circuit diagram using IC LM7805.LM7805 is specially design for +5V positive voltage regulator. This 7805 voltage regulator circuit will provide constant +5V at output. It the schematic circuit you see that i use two capacitor of 10uF, as because it improve the regulation of voltage.

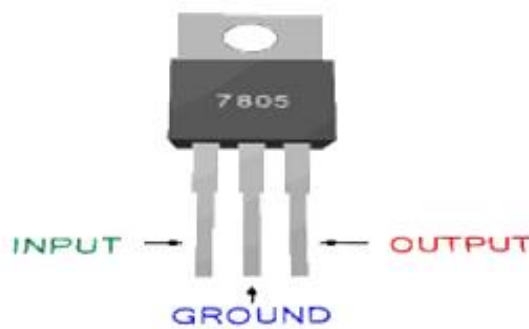


Fig. 4.1: Voltage Regulator

PIN NO.	PIN	DESCRIPTION
1	INPUT	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	In this pin where the ground is given. This pin is neutral for equally the input and output.
3	OUTPUT	The output of the regulated 5V volt is taken out at this pin of the IC regulator.

4.1.1 Description of Voltage Regulator Circuit

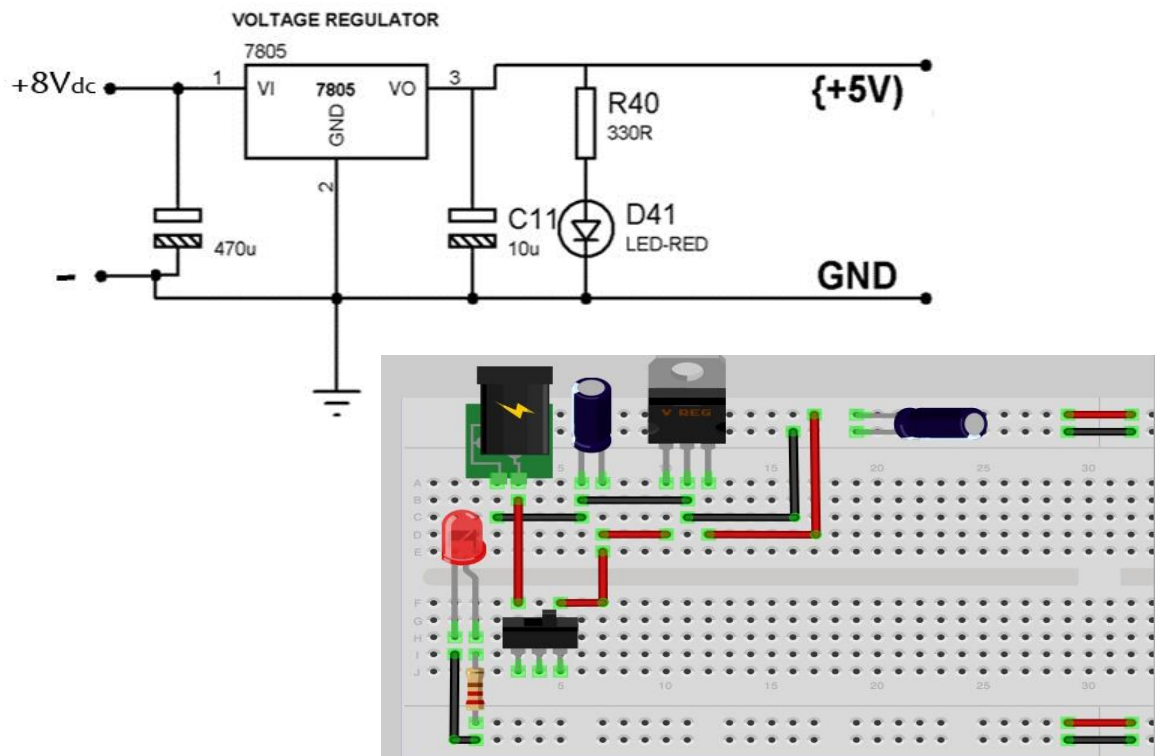


Fig. 4.2: Voltage Regulator Circuit

A regulated power supply is very much essential for several electronic devices due to the semiconductor material employed in them have a fixed rate of current as well as voltage. The device may get damaged if there is any deviation from the fixed rate. The AC power supply gets converted into constant DC by this circuit. By the help of a voltage regulator DC, unregulated output will be fixed to a constant voltage. The circuit is made up of linear voltage regulator 7805 along with capacitors and resistors with bridge rectifier made up from diodes. From giving an unchanging voltage supply to building confident that output reaches uninterrupted to the appliance, the diodes along with capacitors handle elevated efficient signal conveyer.

4.2 Block Diagram

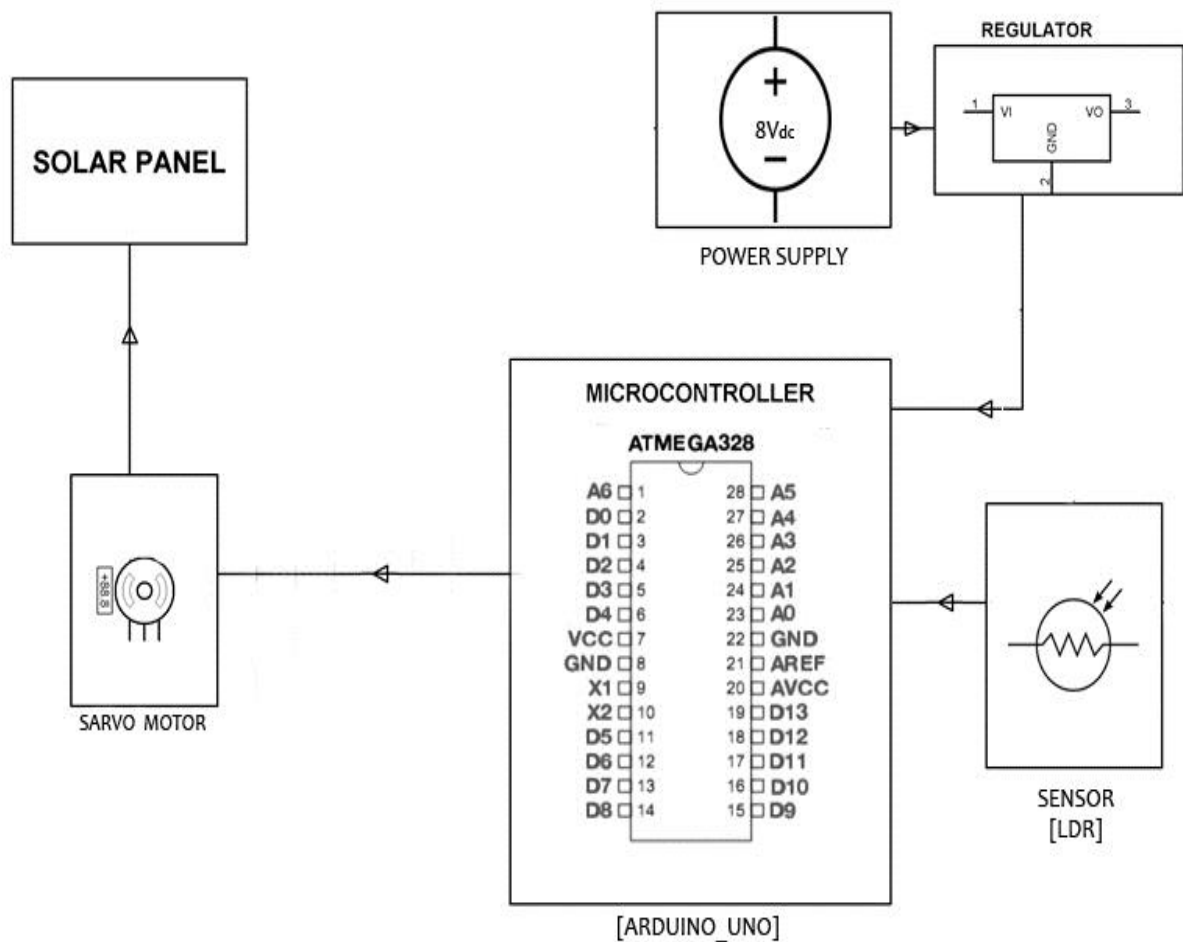


Fig.4.3: Block Diagram of solar tracker using MPPT system with an Arduino

4.3 Circuit Diagram

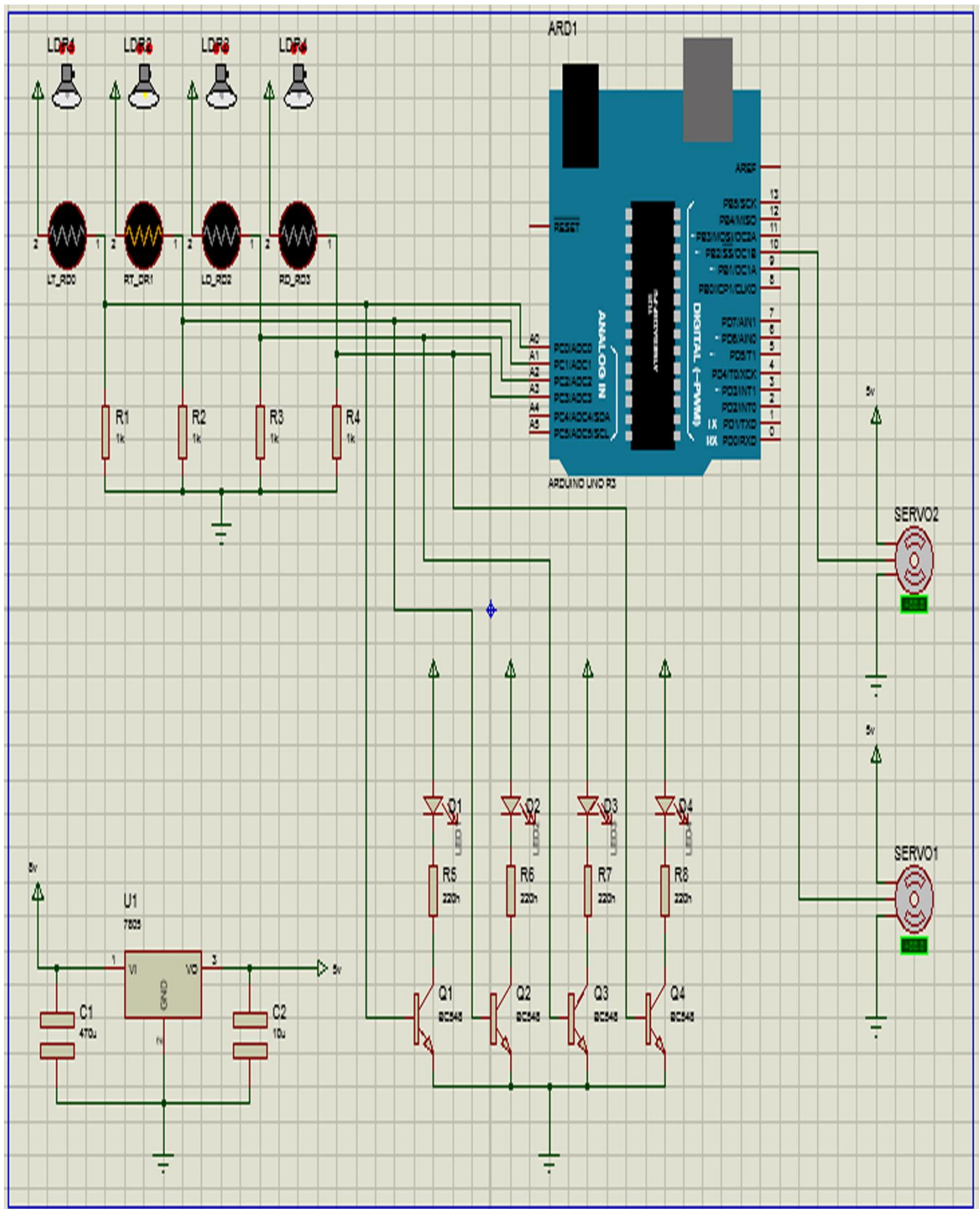


Fig.4.4: Circuit Diagram of solar tracker using MPPT system with an Arduino

4.3.1 Working principal of this Circuit

This circuit shows that the fixed 5v voltage regulator output is connected in Arduino power input. Because fixed 5v is needed to active an Arduino and also shows that the voltage regulator is connected in parallel with all other parameters in this circuit.

When the light falls on the first sensor or LDR. Then the sensor or LDR is active and the output LDR signal is follows in the Arduino analog input pin Ao. Then the programmable logic function of Arduino is active. According to our program which is burn/loaded before in Arduino, The digital output pin D9 gives 0 as a result the horizontal servo motor is active and rotate 180° left to right.

Similarly when light falls on LDR₂ then the Arduino analog pin A₂ is active and then according to our program digital output pin D9 gives 1 and the horizontal servo motor rotate 180° right to left.

Similarly when light falls on LDR₃ and LDR₄ then the analog input pin A₃ and A₄ is active and according to our program digital pin D10 gives 0 and 1 and the vertical servo motor rotate 180° left to right and right to left. And also shows that when LDR₁ is active then the T₁ is active because T₁ base is connected in the LDR₁ output and hence LED₁ is ON. Similarly when light is falls LDR₂, LDR₃, LDR₄ then LED₂, LED₃, LED₄ is ON.

4.3.2 Connection Diagram

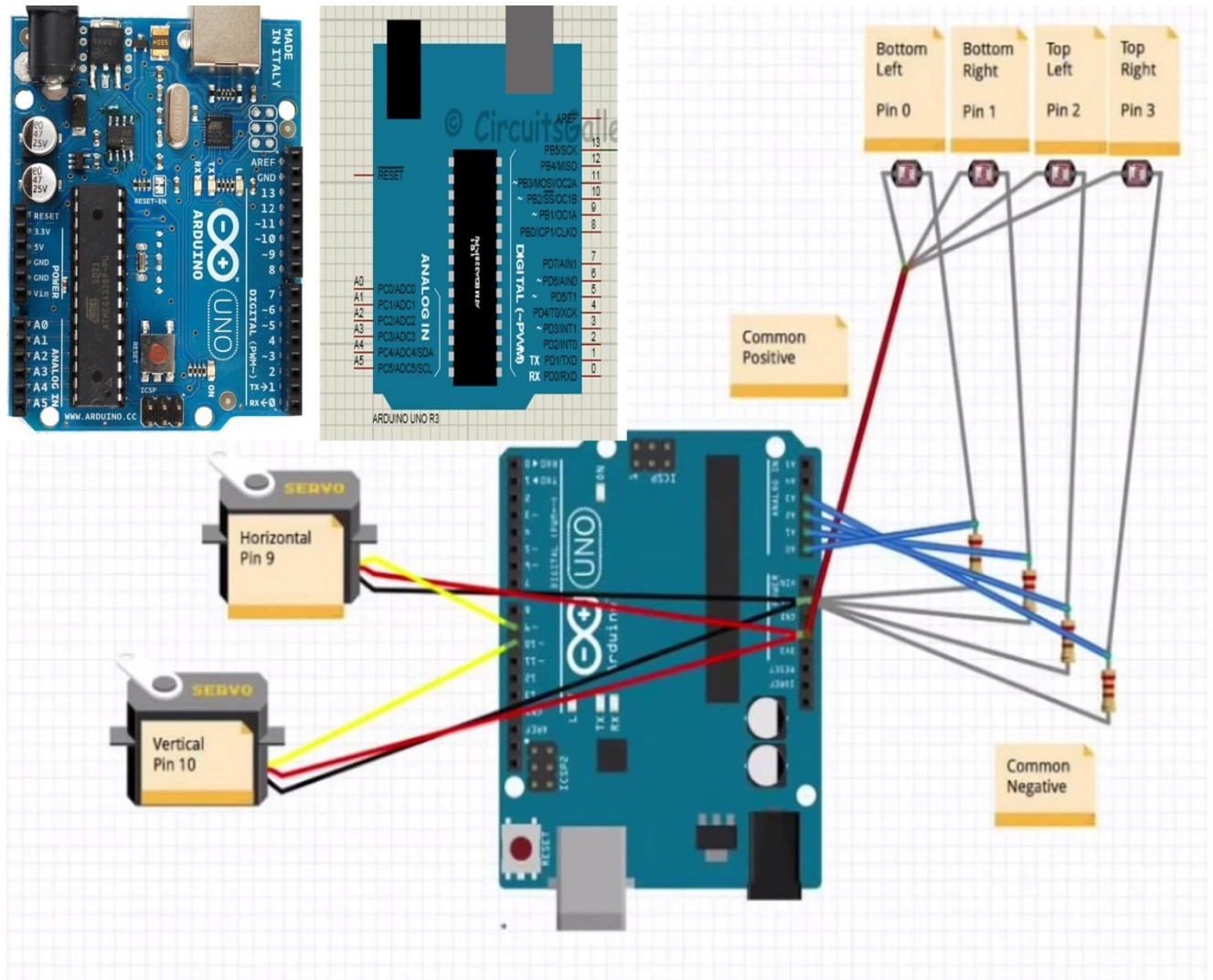


Fig.4.5: Connection Diagram

4.4 Servo Motor Assembly Guide

There are several pieces for this project that need to be assembled. Start by putting the Pan/Tilt Bracket together using the assembly guide from the product. This will show you how to put the bracket together and install the servos for controlling the bracket's orientation.

Once the Pan/Tilt Bracket has been assembled we need to find a way to mount the webcam onto the bracket. I'm using a Logitech Webcam that we lying around the office. It came on this little mounting swivel so that you can hang it from the top of a monitor.

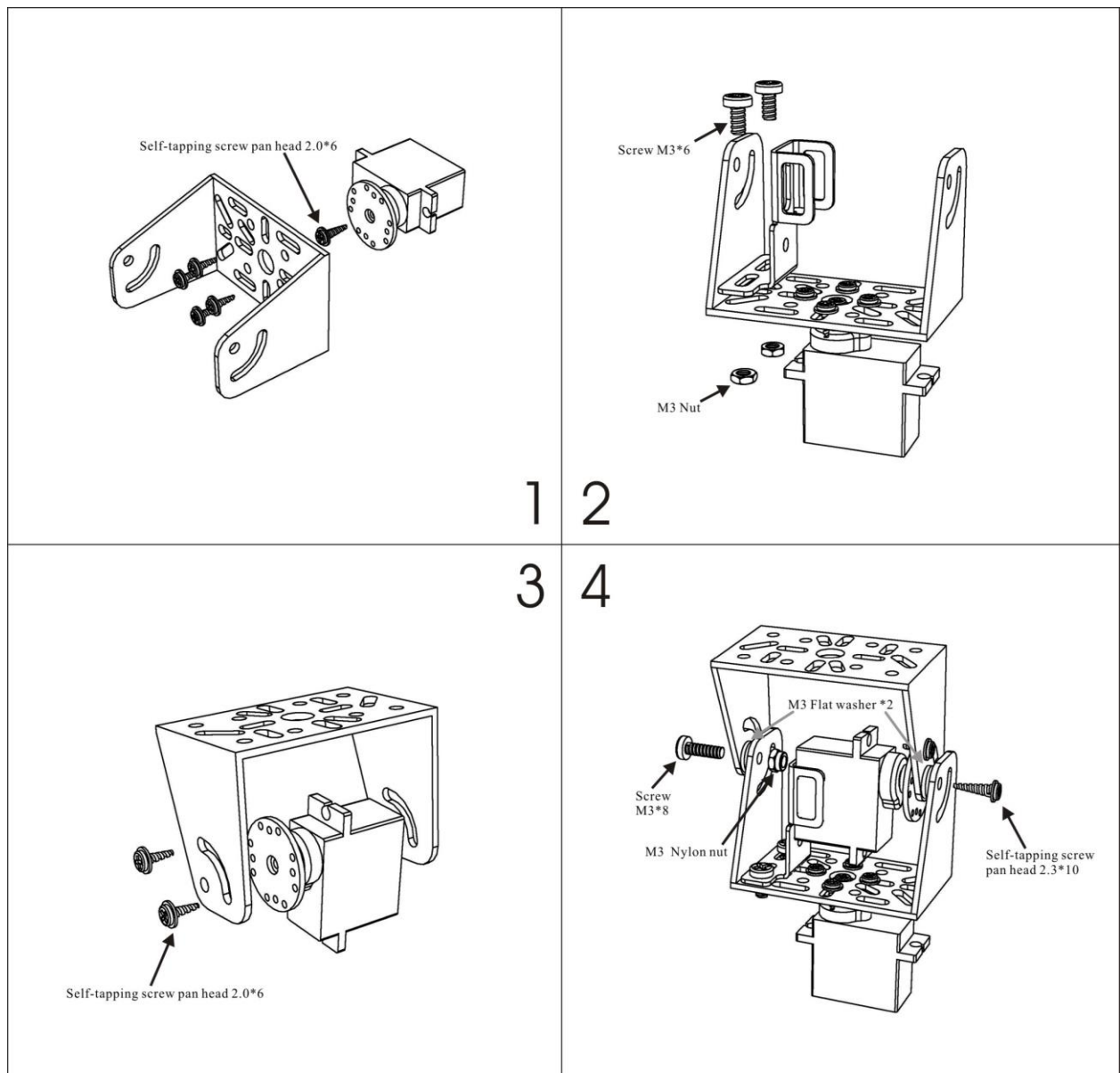


Fig.4.6: Servo Motor Assembly Guide

4.5 Final Project View

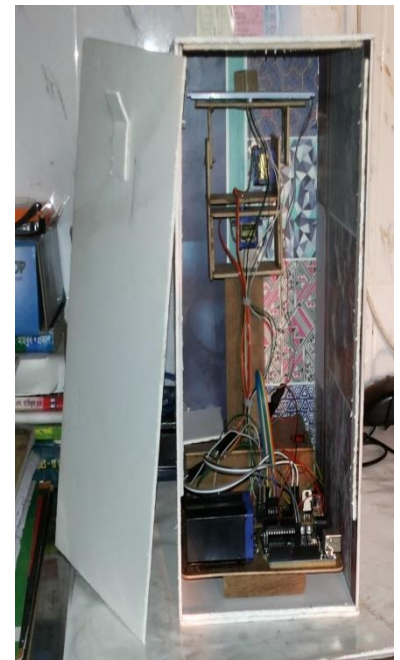
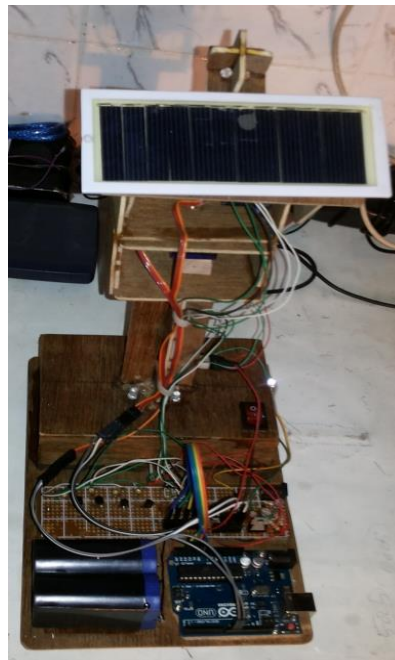
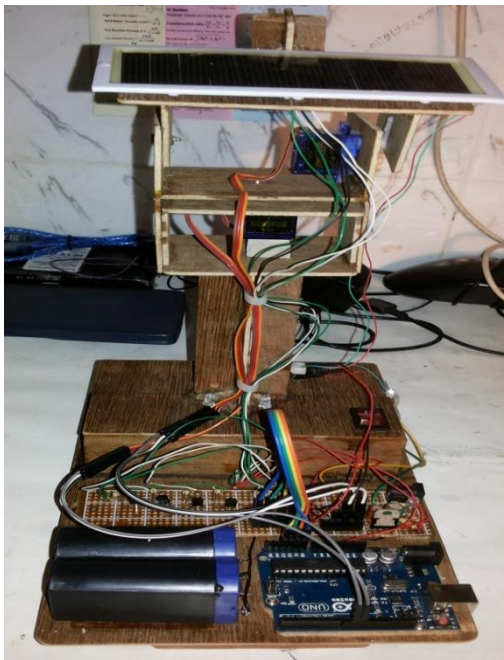
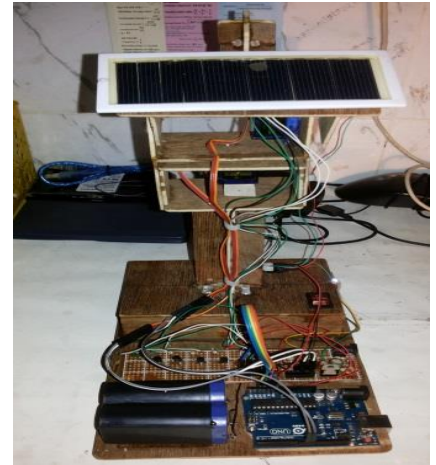
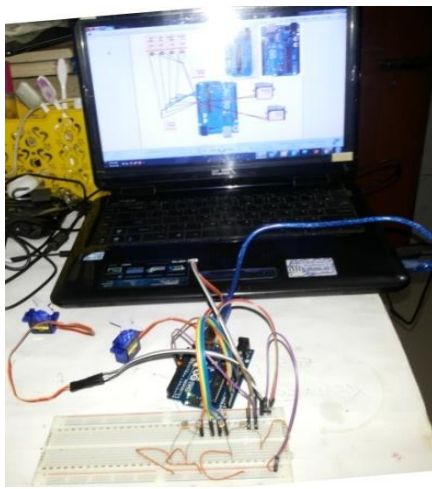


Fig.4.7: Final Project View

4.6 Software Requirements

4.6.1 Definition

Requirements are descriptions of the services that a software system must provide and the constraints under which it must operate. Requirements can range from high-level abstract statements of services or system constraints to detailed mathematical functional specifications.

Requirements Engineering is the process of establishing the services that the customer requires from the system and the constraints under which it is to be developed and operated. Requirements may serve a dual function:

1. As the basis of a bid for a contract
2. As the basis for the contract itself

4.6.2 Requirements Documents

“If a company wishes to let a contract for a large software development project it must define its needs in a sufficiently abstract way that a solution is not predefined. The requirements must be written so that several contractors can bid for the contract, offering, perhaps, different ways of meeting the client organization’s needs. Once a contract has been awarded, the contractor must write a system definition for the client in more detail so that the client understands and can validate what the software will do. Both of these documents may be called the requirements document for the system.”

4.6.3 In this project we use two Softwares

- PROTEUS
- ARDUINO CODER

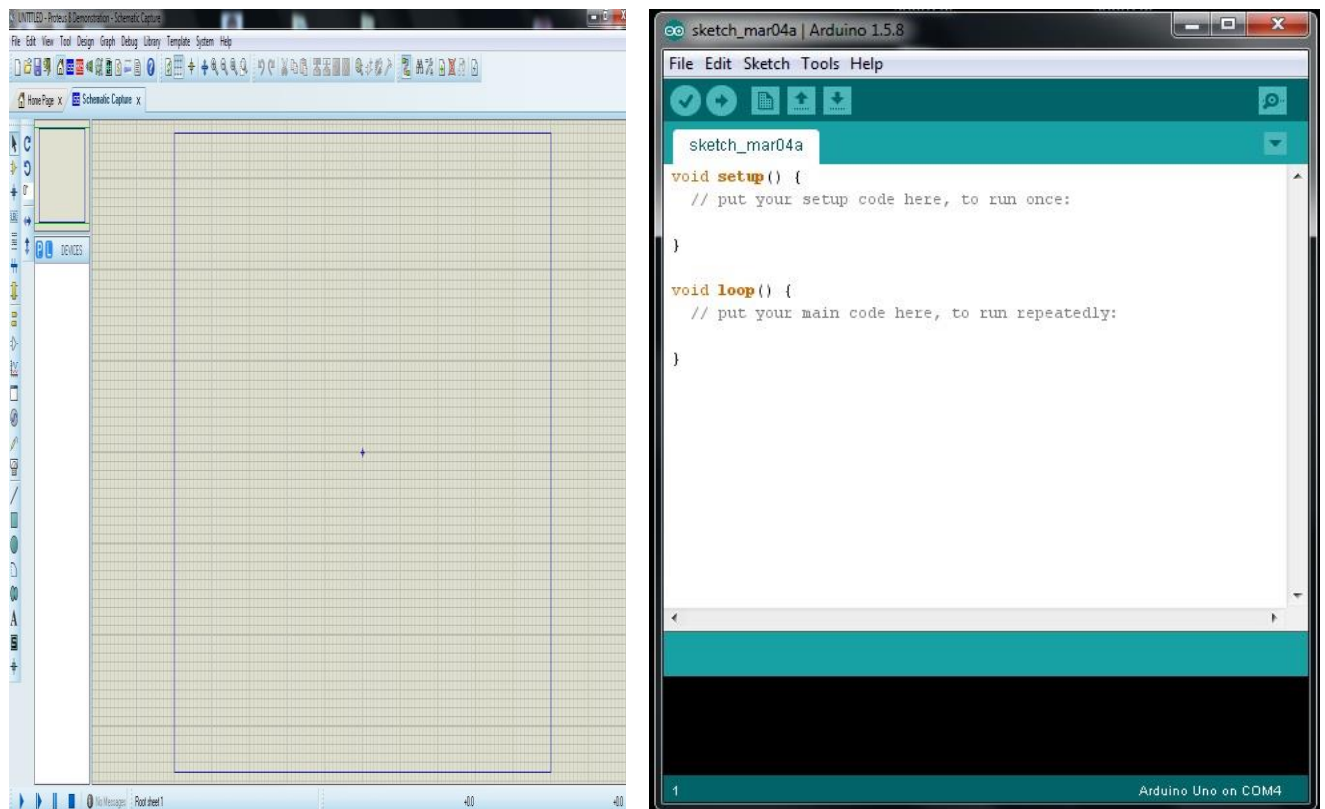


Fig.4.7: PROTEUS&ARDUINO coder windows view

Chapter 5

Conclusion

In simple terms this project's objective is to have a solar panel outputting its maximum possible power all of the time, this occurs when track the sun and rotate the solar panel accordingly, to receive sunlight to the fullest extent always during the day time.

In this project we learned about parameters influencing energy conversion of Photovoltaic (PV) arrays. Also Learned about the general concept of Maximum Power Point Tracking (MPPT) and how to program burn an Arduino.

5.1 The specific work we have finished are as follows

- We tested and optimized the Development board and check the electrical connection between Micro-Controller and servo motor which was used to control the motors smoothly.
- After attaching the Sensor, we successfully developed the program to detect the input signal to control the dc servo motors with Micro-Controller.

5.2 Future Prospects

- Forusing large solar panel, it is necessary to increase the capacity of servo motor. We can use High Torque DC Servo Motor for this purpose.
- For minimize power loss of circuit then we can use logical circuit.
- Ni-Cad Battery can be replaced by Li-ion or Lipo, to increase the power backup time.
- For easily and more efficient control various types of sensors and system can be introduced with this system such as Accelerometer, GPS, Pattern recognition systematic.
- Improving this technology future demand of electricity will be filled up and saved Enormous cost.

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ARDUINO OPERATING CODE

Appendix A

```
#include <Servo.h> // include Servo library
Servo horizontal; // horizontal servo
int servoh = 90; // stand horizontal servo
//
Servo vertical; // vertical servo
int servov = 90; // stand vertical servo

// LDR pin connections
//name = analogpin;
intldr1t = 0; //LDR top left
intldr1r = 1; //LDR top right
intldr1d = 2; //LDR down left
intldr1r = 3; //LDR down right
intledFisso = 13;
int led = 8;
void setup()
{
  Serial.begin(9600);
  // servo connections
  //name.attach(pin);
  horizontal.attach(10);
  vertical.attach(9);
  pinMode(ledFisso, OUTPUT);
  pinMode(led, OUTPUT);
}
void loop()
{
  digitalWrite(ledFisso, LOW);
  digitalWrite(led, LOW);
  int1t = analogRead(ldr1t); // top left
  int1r = analogRead(ldr1r); // top right
  int1d = analogRead(ldr1d); // down left
  int1r = analogRead(ldr1r); // down right

  //intdtm = analogRead(4)/20; // read potentiometers
  inttol = analogRead(5)/4;
  //inttol = 20;
  // inttol = 40;
```

```

intavt = (lt + rt) / 2; // average value top
intavd = (ld + rd) / 2; // average value down
intavl = (lt + ld) / 2; // average value left
intavr = (rt + rd) / 2; // average value right

intdvert = avt - avd; // check the diffirence of up and down
intdhoriz = avl - avr; // check the diffirenceog left and rigt

if (-1*tol>dvert || dvert>tol) // check if the diffirence is in the
tolerance else change vertical angle
{
if (avt>avd){
servov = ++servov;
//      digitalWrite(led, HIGH);
//      delay(1000);          // attende un seconso (1000
millisecondi)
//      digitalWrite(led, LOW);    // spegneil led
//      delay(1000);
//      digitalWrite(led, HIGH);
if (servov> 180){
servov = 180;
}
}
else if (avt<avd){
//      digitalWrite(led, HIGH);
//      delay(100);          // attende un seconso (1000
millisecondi)
//      digitalWrite(led, LOW);    // spegneil led
//      delay(100);
//      digitalWrite(led, HIGH);
servov= --servov;
if (servov< 0){
servov = 0;
}
}
vertical.write(servov);
//delay(15);
}

if (-1*tol>dhoriz || dhoriz>tol) // check if the diffirence is in
the tolerance else change horizontal angle

```

```

    {
    if (avl>avr){
    //          digitalWrite(ledFisso, HIGH);
    //          delay(1000);                // attende un seconso
    (1000 millisecondi)
    //          digitalWrite(ledFisso, LOW);    // spegne il led
    //          delay(1000);
    //          digitalWrite(ledFisso, HIGH);
    servoh = --servoh;

    if (servoh< 0){
    servoh = 0;
        }
    }
    else if (avl<avr){
    //          digitalWrite(ledFisso, HIGH);
    //          delay(100);                // attende un seconso
    (1000 millisecondi)
    //          digitalWrite(ledFisso, LOW);    // spegne il led
    //          delay(100);
    //          digitalWrite(ledFisso, HIGH);
    servoh = ++servoh;
    if (servoh> 169){
    servoh = 169;
        }
    }
    else if (avl == avr){
        // nothing
    }
    horizontal.write(servoh);
        //delay();
    }
    delay(50);
}

```